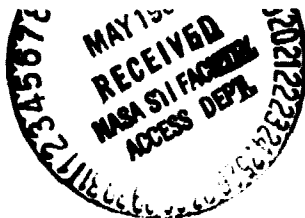


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NASA CASE NO. MFS-25,429-1

PRINT FIGURE 1

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S. N. 596,959  
Filed: 4-5-84

MSFC

APR 19 1984

SPACE PROBE/SATELLITE EJECTION APPARATUS FOR SPACECRAFT

TECHNICAL ABSTRACT

This invention relates to an apparatus for ejecting space probes, satellites, and the like from a spacecraft such as the space shuttle orbiter.

The ejection apparatus is placed within a cylindrical container 15 that is adapted to be carried within the payload bay of the space shuttle orbiter 11 as shown in Figure 1. In Figure 3 the container 15 is shown in cross-section to reveal the ejection apparatus as having a main pneumatic piston-cylinder 21 with a circular cradle 23 attached to the upper end of the piston shaft for supporting the probe/satellite 17. The probe/satellite 17 is secured to the cradle with a unique release mechanism 29, consisting of a retractable pin and locking lug. The cradle 23 is rotatably mounted about a central circular hub 37 that is secured to the shaft 25. A motor 82 having a gear in mesh with a gear track on the cradle rim will cause the cradle to rotate.

In operation, pressurizing gas flows from a supply tank 91 into the pneumatic cylinder 21 forcing the piston and cradle quickly upwardly. The release mechanism 29 securely holds the probe/satellite 17 to the cradle during the initial spin-up operation and ejection acceleration, but releases in an automatic manner the probe/satellite 17 after a limited accelerated travel of the piston.

The novelty of the invention lies in the overall combination of elements that provides a high velocity ejection of a probe/satellite but includes a unique release mechanism that bridges the interface between the ejection apparatus and probe/satellite and permits separation thereof at a desired time.

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## SPACE PROBE/SATELLITE EJECTION APPARATUS FOR SPACECRAFT

### Origin of the Invention

The invention described herein was made by employees of the United States Government and may be manufactured and used by or for the Government for governmental purposes without the payment of any royalties thereon or therefor.

### Technical Field

This invention relates to an apparatus for ejecting space probes, satellites, and the like from a spacecraft, and more specifically to a spin-up and ejection apparatus that is adapted to eject with a significant velocity a spinning payload from a spacecraft such as the orbiter vehicle of the space shuttle. The apparatus includes a retention mechanism that easily disengages from the spinning and accelerating probe or satellite as it leaves the spacecraft. The ejection apparatus may find applications in other technical fields.

### Background Art

On April 12, 1981, a new era in space flight began as the first reusable space shuttle embarked on its first voyage into space. The plane-like element of the space shuttle is the orbiter that carries the crew and payloads. The payloads may include an object such as a satellite that is to be ejected from the payload bay of the orbiter while in flight.

The apparatus for ejecting these objects from the payload bay of the orbiter obtained their motive force from a compressed spring or springs that eject the object with relative low velocity. The objects in the payload bay were retained before release by a retention mechanism which included a clamp, which clamp was cut to release the spring. For those satellites and probes that are spin

stabilized, the entire apparatus including the spring was rotated.

#### Disclosure of the Invention

5 The present invention is versatile apparatus for spinning and propelling objects from the spacecraft at a desired high velocity and rotational speed. This is accomplished without the use of external arms or catapults, or other complex mechanical devices.

10 The apparatus includes a launch cradle or platform on which the space probe or satellite to be ejected rests. The cradle is rotatably secured to the upper end of a pneumatic cylinder piston shaft. Pressurizing fluid flows from a supply tank into the pneumatic cylinder forcing the piston and cradle outwardly at a predetermined velocity  
15 for ejecting the probe or satellite from the space shuttle payload bay.

A mechanism is provided to hold the probe or satellite securely to the cradle during initial ejection acceleration of the piston and spin-up operation of the  
20 cradle, and to release the probe or satellite at the necessary limit of travel of the piston.

Accordingly, it is an object of the present invention to provide an ejection apparatus for space probes or satellite objects from a spacecraft which is capable of  
25 high velocity ejections.

Another object is to provide a versatile apparatus which will spin the probe or satellite object at a desired rotational speed when ejected.

30 A still farther object is to provide a release mechanism for probe or satellite ejection apparatus that will bridge the interface between the ejection mechanism and probe or satellite object that permits separation at the end of a limited ejection movement.

#### Brief Description of the Drawings

35 The invention will be described by referring to the accompanying drawings, in which:

Figure 1 is a side view of the space shuttle orbiter with payload bay sides removed for illustrating the positioning of the containers containing the ejection apparatus of the present invention in the payload bay.

5        Figure 2 is a perspective view of a plurality of containers with ejection apparatus and ejectable loads thereon that is placed in the payload bay of the space shuttle orbiter.

10       Figure 3 is a side view of a single container, partly in section, and with parts broken away revealing the nested ejection apparatus.

Figure 4 is a side view partly in section and with parts broken away of release mechanisms between the probe/satellite loads and ejection apparatus.

15       Figure 5 is a side view similar to Figure 3 showing the release mechanisms at the instant it releases the probe/satellite load, the lower fluid operated retraction pin component is omitted.

20       Figure 6 is a view showing the fluid operated pin retraction component of the release mechanism.

Figure 7 is a sectional view taken along line 7-7 of Figure 3 showing the underside of the circular cradle and circular central hub.

#### Detailed Description

25       Referring to the drawings, wherein in Figure 1 is illustrated a space shuttle orbiter 11 with its payload bay sides removed to reveal a payload pallet 13 holding a plurality of cylindrical containers 15. Upon each container is a probe or satellite 17 object that is to be  
30       ejected. The cylindrical containers 13 have therein the ejection apparatus of the present invention for ejecting the probe/satellite object into space as the orbiter circles the earth.

35       Figure 2 shows in more detail the plurality of containers 15 with their probes/satellites objects 17 secured to a pallet surface 18 of the orbiter.

Figure 3 partly in section illustrates the ejection apparatus 19 of the present invention that is within a container 15. As shown, the ejection apparatus 19 includes a main pneumatic piston-cylinder 21 having a circular cradle 23 attached to the upper shaft 25 of the piston 27 to which the probe/satellite object 17 is secured by release mechanisms 29, each consisting of a retractable pin and a locking lug as will be described below. The piston 27 is adapted to move upwardly very quickly in response to gas emitted in the cylinder 21 to accelerate the probe/satellite object 17 situated on the top of the cradle 23. Before the end of the stroke of the piston 27, the upper release mechanism 29 releases, allowing the probe/satellite object 17 to be thrown out into space in the direction of the piston travel. A pneumatic operated pin component 30 is used to secure the piston-cylinder shaft 25 before gas is admitted into the cylinder 21.

As illustrated in Figure 3 and Figure 4, the circular cradle 23 which fits within the upper opening of the container 13 is adapted to rotate about a circular central hub 37 fastened to the upper or distal end of the piston shaft 25. A circular bearing race 39 is used between the central hub 37 and surrounding 23 cradle. Beneath the central hub 37 is a circular shallow container 41 fastened by bolts 42 to a flange 43 extending from the upper part of the housing for the pneumatic cylinder 21. The bottom of the shallow container 41 has an opening through which the housing of the pneumatic cylinder 21 extends. The pneumatic operated pin component 30 is bolted to the bottom of the shallow container 41 and extends through the side thereof.

As shown best in Figure 4, the circular central hub 37 has a bracket 45 bolted to its underside which has a vertical lug 46 extending downwardly. The gas operated pin component 30 has an elongated pin 31 extending through an opening 49 of the vertical lug 46 to prevent the hub 37 from moving upwardly. The gas operated pin component 30 has an internal piston 50 as shown by Figure 6, which when

gas is emitted under pressure at a forward inlet 51 pushes the piston 50 rearwardly against a helical coil spring 53 and thereby retracts the pin 31 from the hub lug opening 49 (Figure 4). The elongated pin 31 is fastened to the internal piston 50 and extends forwardly through a seal member 55 having an o-ring 56. When the gas pressure is removed, the spring 53 will push the piston 50 forward with its pin 31 reentering the lug opening 49 (Figure 4) if it is still in position. The piston 50 has a rearwardly extending shaft 57, with an enlargement 59 that extends rearwardly of the housing 30. A cam member 61 on the rear end of the piston shaft 59 activates an electrical follower switch 63 so as to provide a signal of its exact position for ground test purposes. The follower switch 63 is not intended for flight purposes.

Referring again to Figure 4, there is shown an upper pin component 29 fastened by bolts 28 to the underside of the cradle 23 and positioned generally within the upper space defined by the shallow container 41 secured to the cylinder housing 21. The space probe/satellite object 17 has a bottom mounting plate 68 with three small openings 69 (Figure 7) extending therethrough. One of the small openings 69 is shown in Figure 4. Across each opening 69 is a bracket 71 which is bolted to the bottom plate 68. The bracket 71 has a downwardly extending vertical lug 72 having a circular opening 73 adjacent its end adapted to receive the elongated pin 75 from a pin component 29. Thus, it should be apparent that the upper pin components 29 fastened to the underside of the circular cradle 23 holds the probe/satellite object mounting plate 68 to the upper surface of the cradle 23. As shown by the underside view of the cradle 23 in Figure 7, three pin components 29, equally spaced, are utilized to removably connect with three corresponding lugs 72 of the probe/satellite object 17. Each lug 72 extending from the probe/satellite object 17 is the same as described above.

Each upper pin component 29 has a cooperating relationship with the vertical side wall 76 of the shallow

container 41 which is explained best by referring both to Figure 4 and to Figure 5. In Figure 5, the pin 75 of the component 29 is shown retracted from the probe/satellite mounting plate lug 72 shortly after the pneumatic cylinder shaft 25 has started the high velocity push that will enable the probe/satellite 17 to be thrown from the cradle 23 into space. This is accomplished by the action of the cradle 23 moving upwardly so that the rear end of the pin 75 which extends rearwardly from the component 29, is free from the upwardly extending side 76 of the container 41 which retains it in position when nested as in Figure 4, but snaps rearwardly by the action of an internal coiled spring 78 shown in Figure 5 when it moves away from the vertical side 76 of the container 41 by upward movement of the main central shaft 25. The pin 75 has an outer annular flange 79 acting within the component housing 29 against which the coil spring 79 pushes using the forward part of the internal housing 29 to force the pin 75 to retract when the rear end of the pin 75 becomes clear of the barrier side wall 76 of the shallow container 41. While three automatically retractable components 29 have been shown, it is readily apparent that the number used may depend on the forces encountered.

As illustrated in Figure 3, the cradle 23 has a circular annular gear track 81 member fastened to its underside adjacent its circular rim edge. The cylindrical container 15 supports a motor 82 therein which has a pinion gear member 83 on its outer shaft which meshes with the internal gear surface of the track member 81. The motor 82 when switched on will cause the cradle 23 to rotate or spin about the central hub 37 so to enable the probe/satellite object 17 to be ejected while spinning. The upper automatic retracting pins 29 when in a nested condition will have the rear end of their pins rubbing against the barrier surface of the vertical side wall 76 of the shallow container 41 when the cradle rotates 23. This does not interfere with retracting pin's operation and when the cradle 23 is lifted causing the retracting

pin component 29 to be clear of the vertical side wall 76 it quickly snaps rearwardly freeing the lug 76 of the bottom plate 68 of the probe/satellite object 17.

5 The upper surface of the circular cradle 23 extends slightly above the central hub 37 so that when the cradle 23 is rotated the bottom plate 68 of the probe/satellite object 17 will not rub against the upper surface of the central hub 37.

10 Safety devices not shown may be incorporated into the apparatus described. For example, crushable aluminum honeycomb structure could be placed in the upper portion of the pneumatic cylinder 21 to slow the velocity of the piston 27 near the end of its stroke. Also, a  
15 spring-loaded solenoid actuated anti-rotation pin could be used to engage the cradle 23 to prevent its rotation.

Figure 3 illustrates the compressed gas container 91 and lines 93, 94 for operating the main pneumatic piston-cylinder 21 as well as the fluid operated retractable pin component 30. As shown the gas, nitrogen  
20 for example, is stored under pressure in a supply bottle 91 supported within the container 75, and has a main inlet line 93, 94 leading therefrom to the bottom inlet of the main pneumatic cylinder 21 and the forward entry 51 of the fluid operated retractable pin component 30. The inlet  
25 line 91 to main inlet lines 93, 94 has a suitable electrical activated valve 96 to emit the gas on signal from the crew members. Depressurization capability is provided by a pyro-actuated vent 97 for abort conditions and an automatic vent after ejection.

30 A return vent line 98 from the upper portion of the main cylinder 21 is provided to release the buildup of a residual gas within the pneumatic cylinder 21 when the piston 27 is forced upwardly by entry of high pressure gas from the supply bottle 91. The lower supply line 94 to  
35 the pneumatic cylinder 21 is longer and of a larger diameter than the upper supply line 93 to the fluid operated retraction pin 30. This enables the gas when released by the valve 96 to reach the fluid retractable

pin component 30 before or simultaneously with the gas reaching the main cylinder 21. Thus, the timing of the gas activation of each component helps ensure that the pin holding the center hub 37 is pulled back to release the center hub 37 before the gas starts pushing the pneumatic piston 27 upwardly.

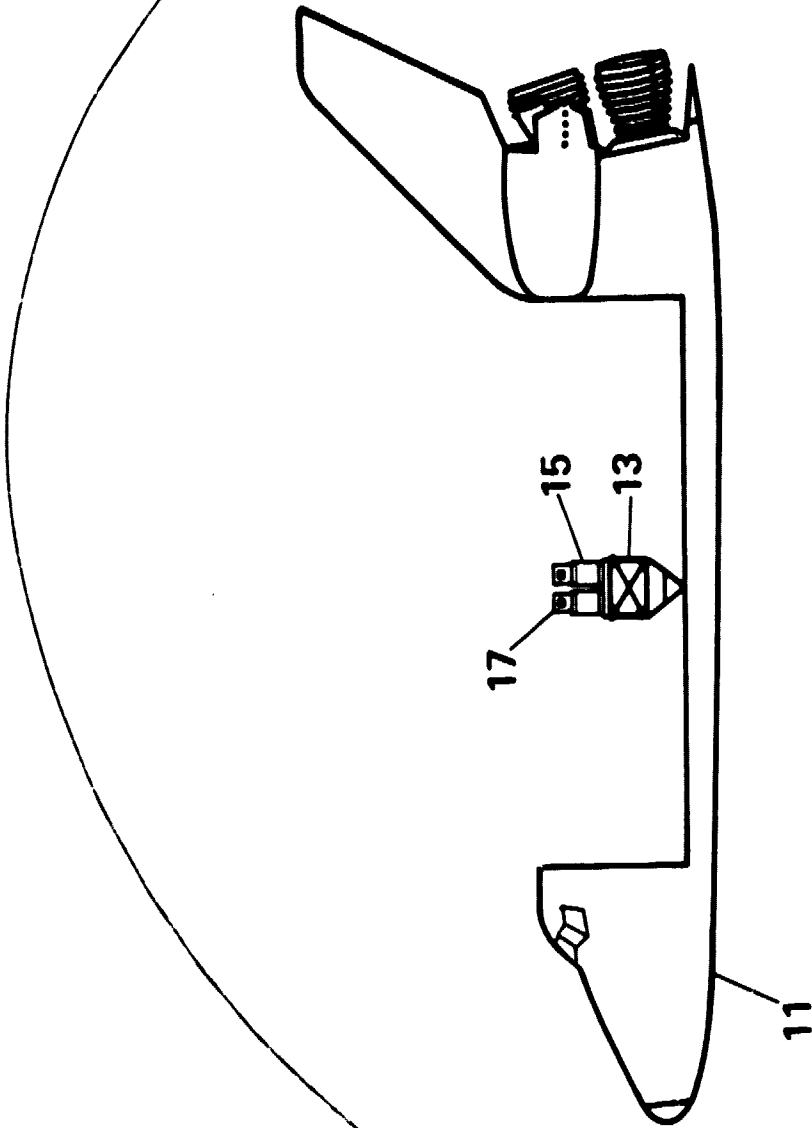
#### Operation

The ejection device is operated when the space shuttle orbiter 11 is at a desired space location for the launch of the probe/satellite object 17. The crew members then activate a signal device (not shown), if the probe/satellite object 17 is to be spin stabilized, starting the motor 82 causing the cradle 23 supporting the probe/satellite object 17 to rotate about the central hub 37 at a desired speed. When the desired rotation speed is reached, the crew members will give the electrical signal to the gas valve 96 causing the release of high pressure gas into the main supply lines 93, 94. The gas upon reaching the retractable pneumatic pin component 30 causes that pneumatic component 30 to retract its pin 31 from the lug 46 attached to the center hub 37. The high pressure gas also activates the main piston 27 causing it to push upwardly within the cylinder 21 the shaft 25. When the piston shaft 25 carries the center hub 37 and surrounding cradle 23 upwardly sufficiently for the automatic retraction pin components 29 to clear the barrier side of the shallow container 41 the retraction pin 75 snaps backwardly from the bottom plate lugs 73 freeing the probe/satellite object 17 from the cradle 23. The entire probe/satellite object 17 and cradle assembly 23 continues to accelerate until the end of the pneumatic piston stroke at which time the probe/satellite object 17 continues to move outwardly so as to be thrown into space.

It is readily apparent that modifications could be made to the ejection apparatus described without departing from the scope of the claim.

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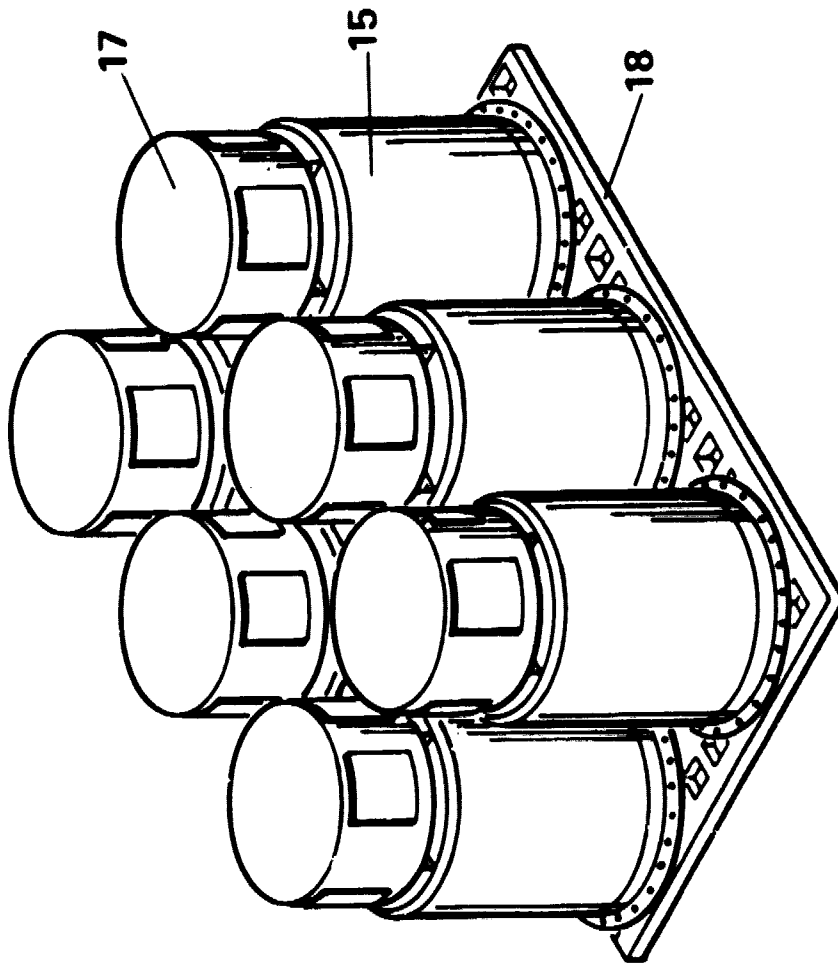


FIG. 2

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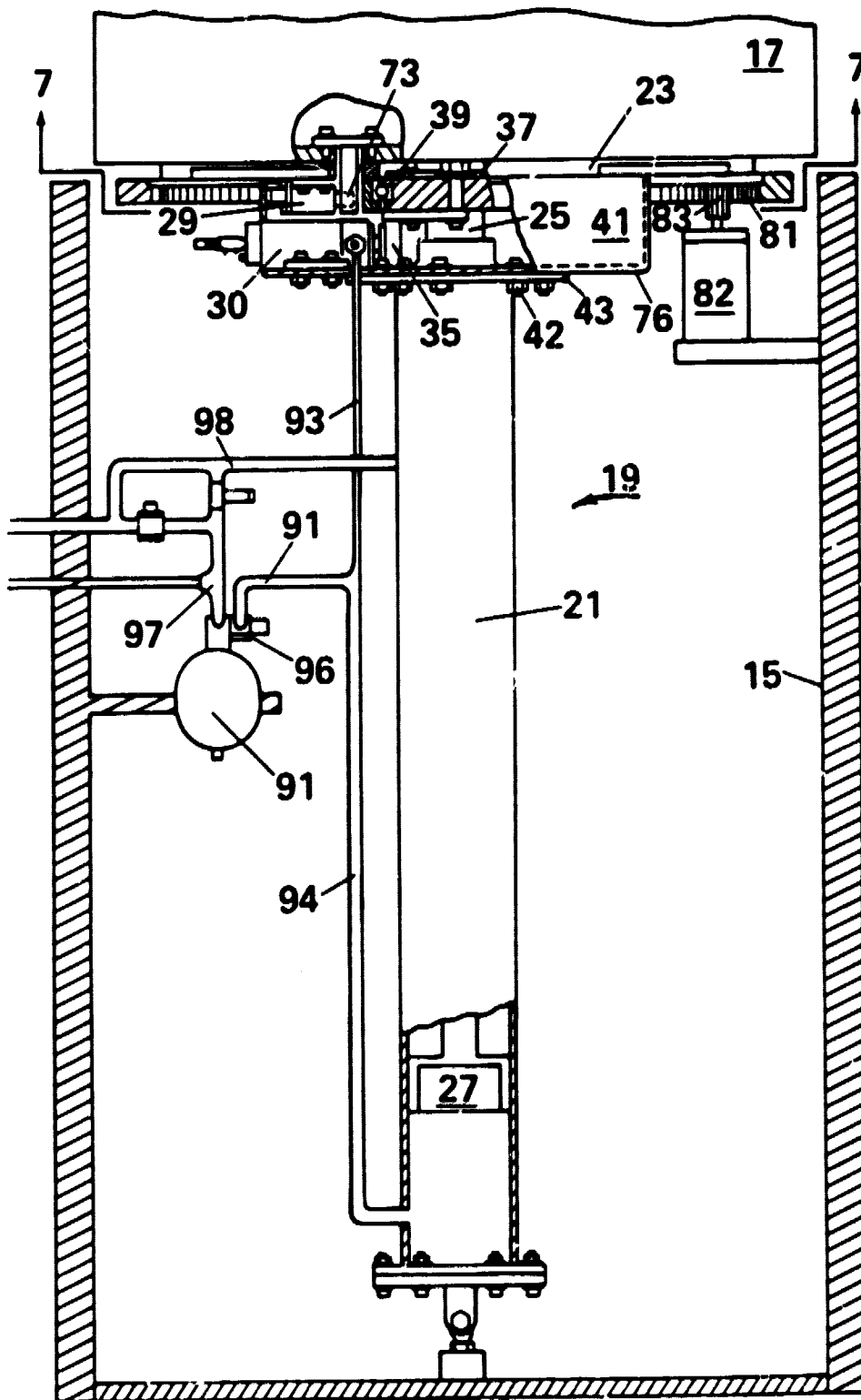


FIG. 3

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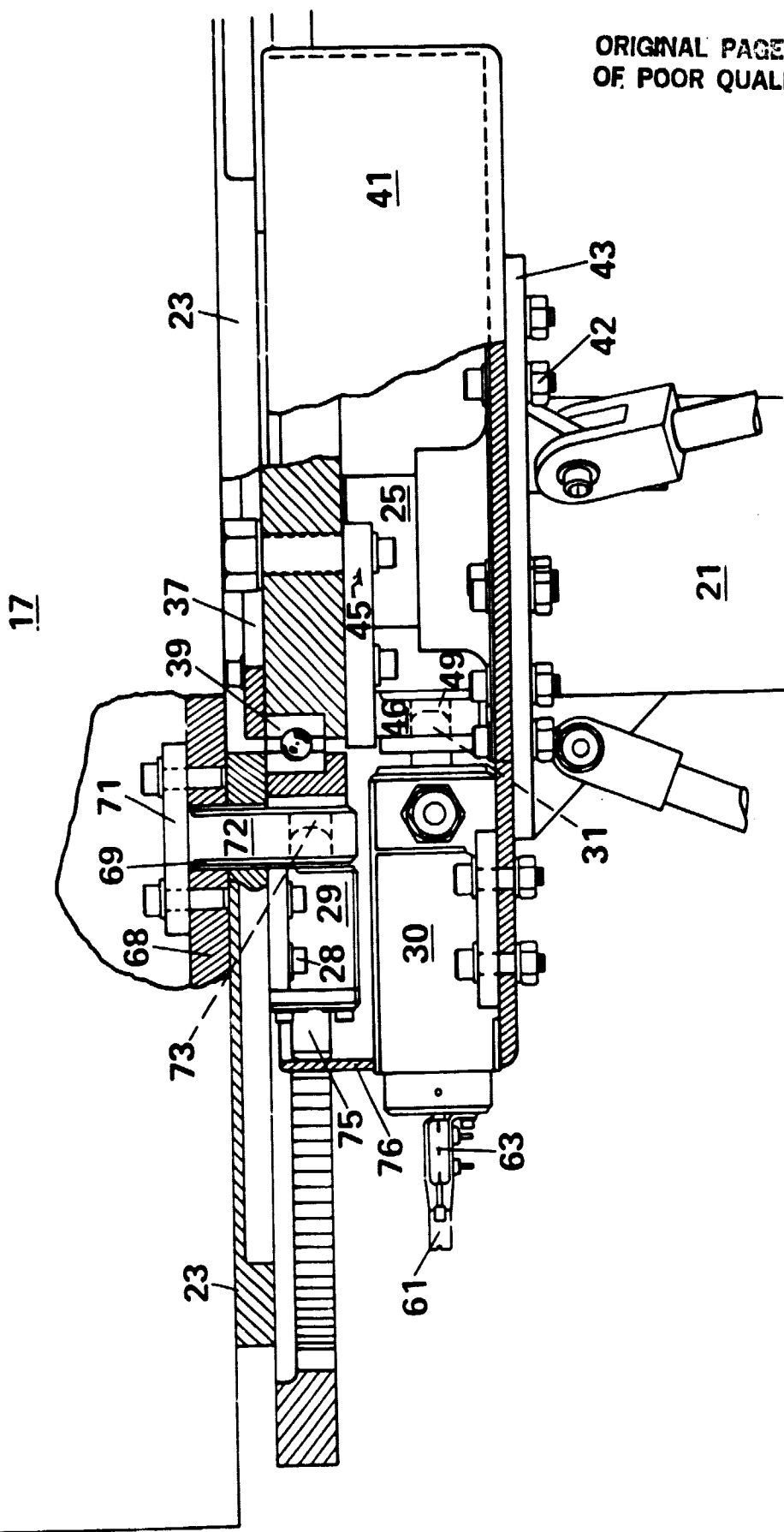


FIG. 4

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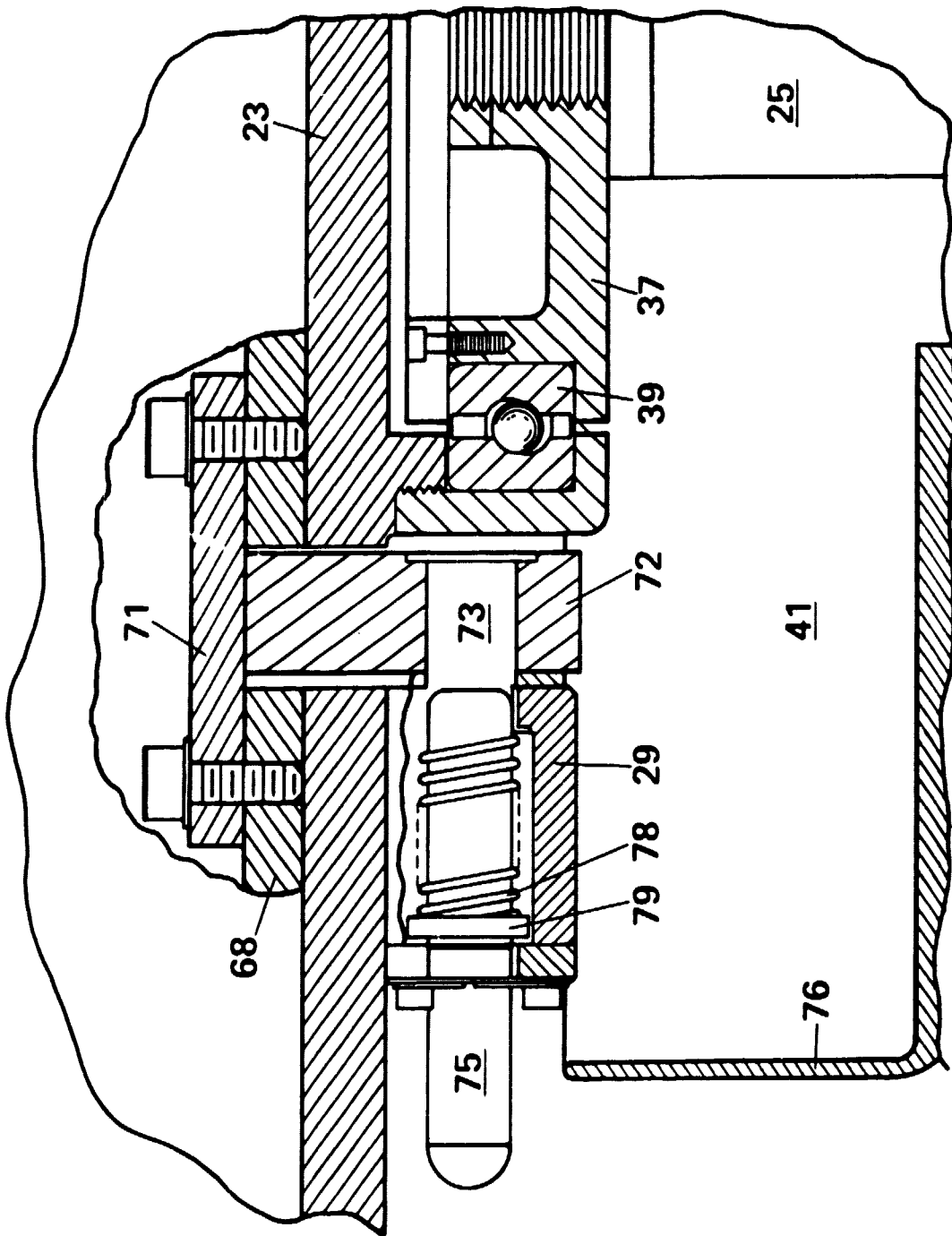


FIG. 5

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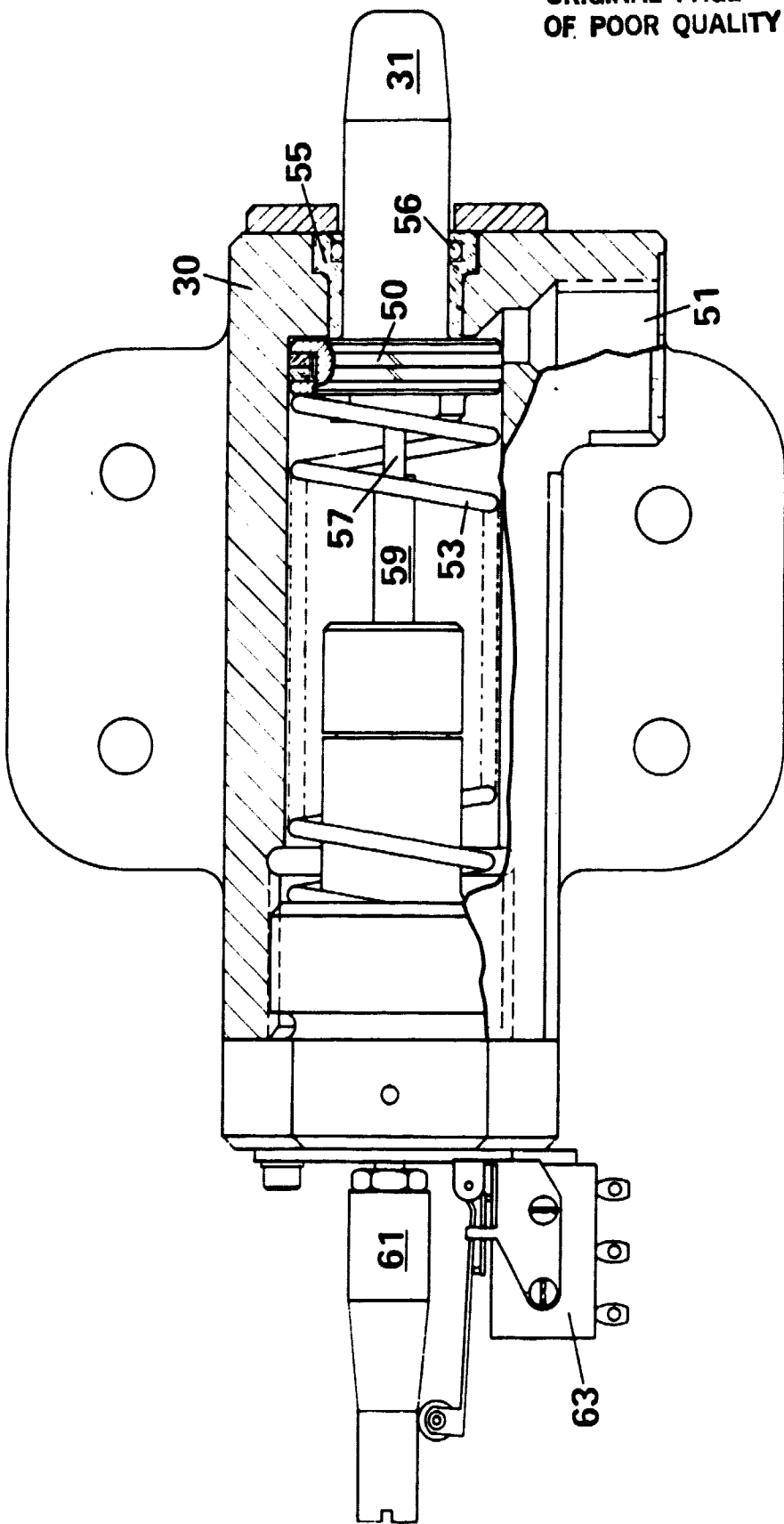


FIG. 6

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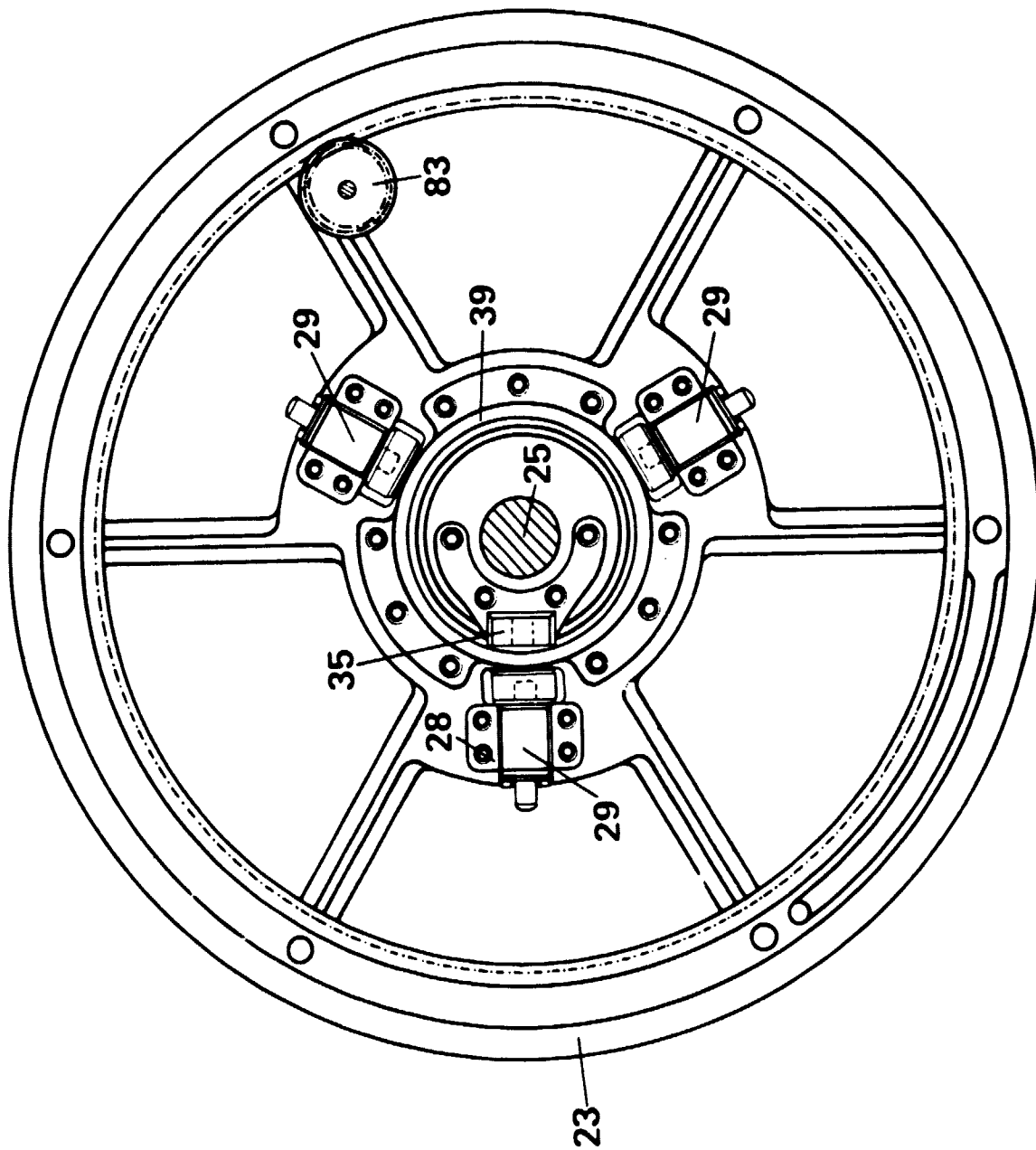


FIG. 7

ABSTRACT OF THE DISCLOSURE

5       An ejection apparatus (19) for spinning and  
propelling objects (17) for ejection from a spacecraft  
(11) at a desired velocity and rotational speed. The  
10       apparatus includes a launch cradle (23) on which the space  
object (17) to be ejected rests. The cradle (23) is  
rotatably supported by a central hub (37) secured to upper  
end of pneumatic cylinder piston shaft (25). Release  
15       mechanisms (29) consisting of a retractable pin (75) and  
locking lug (72) is utilized to hold the cradle and object  
to be ejected. The release mechanism (29) has a fixed  
barrier member (76) which holds the retractable pin (75)  
in engagement with the locking lug (72) until release by  
upward movement of the launch cradle (23) beyond the  
20       barrier height.